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Date 9/10/03 Label No. E306629234-US

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D. DAVIS SINTERED ALLOY AND METHOD OF MANUFACTURING THE SAME

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## BACKGROUND OF THE INVENTION

### 5 Field of the Invention

The present invention relates to a sintered alloy and a method of manufacturing the same.

### Description of the Related Art

10 A porous body is produced for example by sintering metallic or ceramic materials, or by adhesion-bonding of material powders, any of which causes resultant pores on a surface of the porous body so that friction resistance becomes large.

15 Sintered alloys produced by sintering metallic powders are advantageous not only in that they have stable qualities and are suited to mass production, but also in that they enable the use of certain materials of which the composition is very unlikely to be employed if soluble materials are chosen, and thus they have been used for the manufacture of various kinds of members in the past.

20 Conventionally, boron nitride or fluoroplastic materials with excellent lubrication properties have been mixed in the material powders in the case that slidability relative to other members is required, so that a sliding surface with less friction resistance has been formed, as disclosed in Japanese Un-Examined Patent Publication Nos. 10-280083 and 11-50103.

25 According to such conventional structure that fluoroplastic materials or the like are contained in material powers, however, pores remain exposed to the external surface even if lubrication property is improved to an certain extent, and thus surface treatment has been necessary in order to improve air-tightness.

30 On the other hand, sintered alloys have a lot of advantages as

above mentioned, such as stable qualities, mass-production-suited properties, enabling the use of materials whose composition is unlikely to be realized if soluble materials are used, as well as the enabling of the manufacture of porous bodies. By taking advantage of these advantages, 5 different types of sintered products suitable for specific bearings have been widely used in the past, such as those which can save much of lubricant-supplying trouble and are able to be disposed in a place where lubrication is difficult.

In the manufacture of such sintered bearings, material power 10 containing metal powder as a main component is subjected to compacting to form a green compact, using a powder compacting device, and then the green compact thus formed is sintered in a sintering furnace to form a sintered body, which may undergo a sizing process if necessary.

Whereas, relative thrust movement between a bearing and a shaft 15 is generally regulated by a snap ring fixed to the shaft. Between the snap ring and the bearing are disposed a plurality of washers made of rubber or resin such as polyacetal, in order to prevent the abrasion of the snap ring or the oil leakage from a bearing edge of an oil-retaining bearing.

However, washers in direct contact with the bearing are rotated 20 together with the rotation of the snap ring associated by the rotation of the shaft, and thus they are rubbed against the edge of the bearing and eventually worn away. While this problem occurs in the case of the bearings made of soluble metal as well, porous bearings have such porous front surfaces (particularly end faces) that washers are apt to be 25 subjected to abrasion, which is further facilitated due to the increase of friction when a thrust load is applied to the shaft.

Further, if abrasion material of the washers produced by the sliding between the washers and the bearing enters between the shaft 30 and the bearing, the oil exudation from the oil-retaining bearing is hindered, while lubrication material on a surface of "dry bearing" (oilless bearing) is covered with such abrasion powder, and thus there is a

problem that burning or abrasion wear of the shaft is likely to occur. For oil-retaining bearings, even if washers are disposed on the end faces thereof, such washers do not suffice to prevent the oil leakage from the end faces thereof, thus leading to a risk of shortage of lubricant or 5 contamination of peripheral components.

To solve the problem, the end faces of the bearings have heretofore been subjected to lathe cutting process or burnishing process so as to be smoothed and sealed, in order to prevent the abrasion of the washers and the lubricant leakage from the end faces of the bearings. However, the conventional method has had drawbacks that not only manufacturing time and costs increase due to the increase of machine works, but it has been difficult to prevent the abrasion of the washers due to the mutual sliding between the washers and the bearings even after such mechanical works.

## 15 SUMMARY OF THE INVENTION

In view of the above problems, it is, therefore, an object of the present invention to provide a sintered alloy with reduced coefficient of friction and sealed pores on a surface as well as a method of manufacturing the same.

It is another object of the present invention to provide a sintered alloy which prevents of the abrasion of resinous washers rubbed against a bearing body made of such sintered alloy and the lubricant leakage from an end face of the bearing, as well as a method of manufacturing the same.

To attain the objects, there is proposed a sintered alloy according to a first aspect of the invention, including a sintered alloy body which is formed by compacting material powders and then sintering the same,

wherein the sintered alloy body includes a resin film layer and pores, the pores defining a porosity ranging from 2 to 35 volume %, each having an inlet portion and an inside portion, thus defining a pore inlet

diameter and a pore inside diameter,

wherein the pore inlet diameter ranges from 10 to 200  $\mu\text{m}$ , and an average ratio of the pore inlet diameter to the pore inside diameter is at least 2.0.

5 Accordingly, the resin film layer enters into the pores and contacts them so closely that the pores on the surface are sealed.

A sintered alloy according to a second aspect of the invention is the one set forth in the first aspect, wherein the sintered alloy body is a bearing body.

10 Accordingly, the resin film layer is provided integrally on the bearing body, and seals the pores thereon, thus improving sliding properties thereof.

A sintered alloy according to a third aspect of the invention is the one set forth in the second aspect, wherein the resin film layer is 15 provided on at least one of end faces of the bearing body, the end faces being provided on axially opposite ends of the bearing body.

Thus, as the resin film layer serves as a washer member, the relative rotation between the bearing body made of sintered alloy and the washer member made of resin film layer is suppressed, rather resulting 20 to the sliding between the washer member and the other washers, or to the sliding between the washer member and a snap ring, thus ensuring the preventing of the abrasion of the washer member due to the sliding relative to the bearing body. Moreover, as the pores on the end face of the bearing body can be sealed by the washer member, the oil leakage from 25 the end face of the bearing can be prevented effectively.

A sintered alloy according to a fourth aspect of the invention is the one set forth in any of the foregoing aspects, wherein solid lubricant is dispersed in the resin film layer.

Thus, as there is provided the resin film layer in which the solid 30 lubricant is dispersed, the coefficient of friction can be simply reduced. Further, as the resin coating is applied in the form of adhesion matrix,

the washer member can contain comparatively a lot of solid lubricant therein.

A sintered alloy according to a fifth aspect of the invention is the one set forth in the fourth aspects, wherein the solid lubricant makes up 5 1 to 40 volume % of the resin film layer, as it is difficult to obtain friction-reducing effect with the solid lubricant less than 1 volume %, while the strength of the resin film layer is lowered with the solid lubricant more than 40 volume %. Accordingly, it is possible to obtain the friction-reducing effect without lowering the strength of the resin film 10 layer by employing the range proposed in this aspect.

A method of manufacturing a sintered alloy according to a sixth aspect of the invention is the one for manufacturing the sintered alloy set forth in the first aspect, comprising the step of forming the resin film layer on the sintered alloy body, using solid lubricant coating.

15 Although the sintered alloy body has normally a large frictional resistance due to the presence of pores on the surface, the frictional resistance can be simply reduced by providing the resin film layer containing the solid lubricant. Also, the resin film layer enters into the pores and contacts them so closely that the pores are sealed.

20 A method of manufacturing a sintered alloy according to a seventh aspect of the invention is the one set forth in the sixth aspect, wherein the sintered alloy body is a bearing body.

25 Accordingly, the resin film layer is provided integrally on the bearing body, and seals the pores thereon, thus improving siding properties thereof.

A method of manufacturing a sintered alloy according to an eighth aspect of the invention is the one set forth in the seventh aspect, wherein the resin film layer is provided on at least one of end faces of the bearing body, the end faces being provided on axially opposite ends of said 30 bearing body.

Thus, as the resin film layer integrated with the bearing body

serves as a washer member, the relative rotation between the bearing body made of sintered alloy and the washer member made of resin film layer is suppressed, rather resulting to the sliding between the washer member and the other washers, or to the sliding between the washer member and a snap ring, thus ensuring the preventing of the abrasion of the washer member due to the sliding relative to the bearing body. Moreover, as the pores on the end face of the bearing body can be sealed by the washer member, the oil leakage from the end face of the bearing can be prevented effectively.

10 A method of manufacturing a sintered alloy according to a ninth aspect of the invention is the one set forth in any one of the sixth to eight aspects, wherein the resin film layer is pressed against the sintered alloy body after forming the resin film layer.

15 Accordingly, the pressing of the resin film layer facilitates the resin film layer to enter into the pores of a porous body, thus improving the tightness therebetween, while smoothing the surface, eliminating the need for preliminary leveling process.

20 A method of manufacturing a sintered alloy according to a tenth aspect of the invention is the one set forth in the ninth aspect, wherein the pressing is performed by a sizing process.

Accordingly, the pressing process is performed simultaneously with the sizing of the sintered alloy body, thus realizing the tightness of the resin film layer as well as the smoothing of the surface.

25 A method of manufacturing a sintered alloy according to an eleventh aspect of the invention is the one set forth in any one of the sixth to eight aspects, wherein the resin film layer is formed by a printing process of the solid lubricant coating.

30 Accordingly, the printing process allows the resin film layer to enter into the pores and closely contacts them, thus sealing the pores on the surface.

A method of manufacturing a sintered alloy according to a twelfth

aspect of the invention is the one set forth in the eleventh aspect, wherein the printing process is a screen printing process.

Thus, as the resin film layer is provided by screen printing process, even a comparatively thick resin film layer can be formed easily by the 5 screen printing as compared with conventional process such as spray coating process. Further, by the screen printing process, the resin film layer can be formed to a desirable pattern more simply than by other processes.

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#### BRIEF DESCRIPTION OF THE DRAWINGS

For more complete understanding of the present invention, reference is now made to the following description taken in conjunction with the accompanying drawing, in which:

15 Fig.1 is cross-sectional view illustrating a screen printing in accordance with a first embodiment of the invention.

Fig.2 is a cross-sectional view illustrating a step of pressing a resin film layer to a sliding surface in accordance with the first embodiment of the invention.

20 Fig.3 is a micro photographic view showing a sintered alloy body prior to a sizing process in accordance with an embodiment of the invention.

Fig.4 is a flow chart showing a manufacturing method in accordance with another embodiment of the invention.

25 Fig.5 is a cross-section of a sliding member in accordance with the second embodiment of the invention.

Fig.6 is a cross-section illustrating a tissue at an end face of the sliding member in accordance with an embodiment of the invention.

30 Fig.7 is a cross-sectional view illustrating a sizing process in accordance with an embodiment of the invention.

Fig.8 is an explanatory diagram showing a surface roughness of a

resin film layer, in which Fig. 8(A) shows the same before the sizing process, while Fig.8 (B) the same after the sizing process.

Fig.9 is a plan view showing a sliding member in accordance with an embodiment of the invention.

5 Fig.10 is a cross-sectional view illustrating the sliding member in accordance with an embodiment of the invention.

Fig.11 is an explanatory cross-sectional view illustrating a screen printing in accordance with an embodiment of the invention.

10 Fig.12 is a partly enlarged cross-sectional view showing a sliding member in accordance with an embodiment of the invention.

Fig.13 is a flow chart showing a manufacturing method in accordance with an embodiment of the invention.

Fig.14 is a cross-section of a shaft and a sintered bearing in accordance with an embodiment of the invention.

15 Fig.15 is a cross-sectional view illustrating a tissue at a boundary surface between a bearing body and a resin film layer in accordance with an embodiment of the invention.

Fig.16 is a cross-sectional view illustrating a screen printing in accordance with an embodiment of the invention.

20 Fig.17 is a cross-section of a shaft and a sintered bearing in accordance with an embodiment of the invention.

Fig.18 is a cross-section of a shaft and a sintered bearing in accordance with an embodiment of the invention.

25 Fig.19 is a cross-section of a shaft and a sintered bearing in accordance with an embodiment of the invention.

#### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Hereunder is a description of embodiments of the present 30 invention with reference to the attached drawings.

In Figs.1-3 showing an embodiment of the invention, reference

5 numeral 1 designates a sintered alloy body whose porosity is in a range of from 2 to 35 volume % in this embodiment. The sintered alloy body 1 is a sliding member having a sliding surface 2, which is formed with a resin film layer 3 as a printed layer, using solid lubricant coating 110 or the like. The resin film layer 3 thus formed is pressed against the sliding surface 2 to thereby bring the resin film layer 3 into close contact with the sliding surface 2.

10 The aforesaid sintered alloy body 1 has pores each having a diameter of 10 to 200  $\mu\text{m}$  (preferably of 20 to 100  $\mu\text{m}$ ) at its inlet side (hereinafter called "pore inlet diameter), and that an average ratio of the "pore inlet diameter" to a "pore inside diameter" is at least 2.0 in the said pore (preferably in a range from 2 to 20, more preferably from 5 to 20). As above described, porosity here is in the range of 2-35 volume % (preferably 10 to 25 volume %).

15 The aforesaid sintered alloy 1 is obtained by mixing material powders mainly composed of metal in a preset mixing ratio, performing a blending process for well blending the material powders, and then forming the same into a green compact of a predetermined configuration by applying a preset pressure thereto, and then sintering the green 20 compact.

25 For the resin coating which forms the resin film layer 3 may be used the coating of solid lubricant coating. Coating methods thereof may be for example a tumbler method in which an object to be coated is put in a tumbler, and then solid lubricant coating is sprayed to the object while being stirred by circulating or vibrating the tumbler; a spray method in which solid lubricant coating is sprayed from a spray gun to the object; and a dipping method in which the object is dipped in solid lubricant coating. Further, when the solid lubricant coating is applied to a limited 30 predetermined section on a surface of the object, a masking tape or the like may be attached to a portion to which no coating is to be applied, and then spray coating is applied, and the masking material is removed

thereafter.

The solid lubricant coating 110 for use with printing maybe produced by dispersing a large amount of fine particles of solid lubricant in binder solution, said binder solution being obtained by solving binder 5 resin in solvent. For such binder resin may be used polyamide-imide resin, epoxy resin, furan resin, melamine resin, acrylic resin, urethane resin or the like. Taking adhesion and mechanical strength into consideration, however, it is desirable to use two-component system epoxy of amine hardening type. For solvent may be employed xylene, toluene, butanol, 10 isobutylalcohol, isopropylalcohol, dioxane, methyl ethyl ketone, N-methyl-2-pyrrolidone or the like. For solid lubricant may be employed PTFE (polytetrafluoroethylene, i.e., "Teflon" (registered trademark), PFA (polytetrafluoroethylene-perfluoroalkylvinylether copolymer, i.e., "Teflon" (registered trademark), C (graphite), MoS<sub>2</sub> (molybdenum disulfide), BN 15 (boron nitride), WF (tungsten fluoride), and TiN (titanium nitride) or the like, which may be used alone or in a mixture thereof. To the solid lubricant coating may be added dispersant, antifoamer, stabilizer, fire retardant, hardening accelerator, pigments and the like.

Silkscreen printing is one of desirable printing methods. 20 Silkscreen printing is a kind of stencil printing. As illustrated in Fig.1, meshed silk, nylon, Tetron, or stainless steel is put on a frame 111 to thereby provide a screen 112, which is formed with a pattern formation layer 113 forming a part that the solid lubricant coating 110 or ink passes through and a part that it does not, so that the ink on the screen 112 is 25 pushed out with a squeegee 114 so as to print a desirable figure on the surface of an object.

In some embodiments, printing is performed with a 3-6mm clearance between the said screen 112 and the surface of the object. Silkscreen printing is advantageous in that plate making is easy and 30 inexpensive, and a printing machine therefor has a simple structure and is easy to use. Particularly in the case that ink is the solid lubricant

coating 110, solid lubricant fine particles of large specific gravity is prevented from being separated due to the solid lubricant coating 110 supplied on the screen 112 being always stirred by the squeegee 114, and thus there is an advantage that the resin film layer 3 of high quality is 5 able to be obtained. Moreover, silkscreen printing is suitable for printing a flat surface such as the end face 11A.

In the meantime, printing methods of the invention should not be limited to the silkscreen printing, but other printing method such as pad printing, for example, may be used. In the pad printing, the resin film 10 layer 3 can be printed by pressing a transcriptional pad against an object to be printed after the transcriptional pad is pressed against a printing plate coated with the solid lubricant coating 110 to attach the ink prescribing a predetermined pattern thereto. In the event that the printing of the solid lubricant coating 110 is performed by other printing 15 methods than the silkscreen printing, it is desirable to provide a stirring device in an ink reservoir of the printing machine, and to always stir the solid lubricant coating 110 during printing in order to prevent the solid lubricant from being separated. The resin film layer 3 thus formed has the aforesaid solid lubricant dispersed in a proportion of 1-40 volume %.

20 According to the foregoing silkscreen printing method, it is possible to determine the thickness of a printing layer of the solid lubricant coating 110 depending on the thickness of the pattern formation layer 113. For example, with the printing layer of 200  $\mu\text{m}$  thickness, dry thickness after baking processing at about 80 degrees centigrade becomes 25 about 60-70  $\mu\text{m}$ .

One of preferred examples of the lubricant coating 110 is a mixture of 100 parts by weight of screen process ink for metal coating (product name: "SS25-000" by Toyo Ink Seizo K.K., epoxy resin) and preferably 10 to 30 parts by weight of PTFE having an average particle 30 diameter 20-50,  $\mu\text{m}$  to which is further added preferably 5 to 20 parts by weight of exclusive solvent to obtain a suitable viscosity for printing, thus

obtaining the ink for screen printing.

In the printing layer, the solid lubricant having small surface energy is exposed to the surface side thereof, thus increasing the density of the solid lubricant on the surface side of the resin film layer 3, 5 displaying an excellent sliding characteristic.

It is preferable to fully degrease the surface of the sintered alloy body 1 prior to the printing of the solid lubricant coating 110 so as to perform preliminary surface adjustment. In the event that the sintered alloy body 1 is an iron-based one, blast processing or the like may be 10 performed as such surface adjustment. It is also preferable to preheat the sintered alloy body 1 at the time of the printing of the solid lubricant coating 110 in order to remove moisture from the surface of the sintered alloy body 1 and to improve the durability of the resin film layer 3. Although, the resin film layer 3 is subjected to baking process after the 15 printing of the solid lubricant coating 110, it is preferable to dry the resin film layer 3 temporarily prior to the baking process in order to protect the resin film layer 3 during the transportation to a heating furnace.

The solid lubricant coating 110, includes a large amount of the solid lubricant fine particles dispersed in the binder solution, is applied 20 by screen printing process, it is possible to perform printing process more easily and at lower costs, as compared with the coating by spray gun, preventing the dispersion of the coating while reducing the loss of coating, thus preventing the solid lubricant coating from adhering to unnecessary portions.

25 Fig.3 is a microgram (495x) of the sintered alloy body 1 prior to sizing process. Preferred solid lubricant coating is ink for use with metal coating, such as "SS25-000" (epoxy resin) and/or "SS16-000" (urethane resin) made by Toyo Ink Seizo K.K. PTFE is dispersed in them, and the resin film layer 3 thus obtained includes about 30 volume % of PTFE in a 30 dispersed state. It is understood that the resin film layer 3 enters into the pores, in close contact therewith, while the surface of the resin film layer

3 is comparatively flat even before sizing process.

After the resin film layer 3 is provided integrally with the sintered alloy body 1 in the above-mentioned manner, the resin film layer 3 is pressed against the sliding surface 2 of the sintered alloy body 1. For instance, the resin film layer 3 may be pressed against the sliding surface 2 by a pressing means 4 which abuts to the surface of the resin film layer 3 and presses the same toward the sliding surface 2, as illustrated in Fig.2, so that the resin film layer 3 enters the pores on the sliding surface 2 to be brought in close contact therewith, thus eliminating or relieving the need for surface preparation of the sliding surface 2 such as chemical surface treatment thereof prior to the formation of the resin film layer 3 by printing.

In the meantime, it is desirable that the thickness T of the said resin film layer 3 is 0.1 mm or more.

In Figs.4 to 7 showing a second embodiment of the invention, the same portions as those described in the foregoing embodiment will be designated by the same reference numerals, and their repeated detailed description will be omitted. Meantime, the omission of repeated detailed descriptions will apply to any of hereinafter-described third or later embodiments as well.

After a raw material powder mainly composed of metal is mixed in a preset mixing ratio and the resultant mixture is subjected to blending process (S1: step 1), it is formed into a green compact of a preset shape by applying a preset pressure thereto, using a press (S2). Then, the green compact is subjected to sintering process (S3) to form the aforesaid sintered alloy body or a bearing body 11. Then, the solid lubricant coating 110 is applied to one end face 11A of the bearing body (S4) to form the resin film layer 3. The bearing body 11 formed with the resin film layer 3 thus way is subjected to sizing process (S5) as a re-compression process, and then finished to a preset size. By this sizing process (S5), the resin film layer 3 is pressed against the end face 11A serving as a sliding

surface. Incidentally, for said application of coating (S4) is preferably used a printing method.

The bearing body 11 is a cylindrical sintered body obtained by sintering a green compact formed by compacting metallic raw material 5 powders such as iron and copper. The bearing body 11 is a sliding member including a through-hole 12 in the center thereof, rotatably supporting an axial body 13 serving as a rotating element on an inner peripheral surface of the through-hole 12. Numeral 14 is a ring integrally fixed to the axial body 13, said ring 14 regulating the thrust movement of the 10 axial body 13 by contacting the resin film layer 3 formed on the end face 11A of the bearing body 11. As above described, the bearing body 11 is a sintered body obtained by sintering a green compact formed by compacting metallic raw material powders such as iron and copper, which is so-called oil-retaining bearing which impregnates the sintered body 15 with oil.

As for the surface of the end face 11A of the bearing body 11, the bearing body 11 has a pore 101 having an inlet diameter  $\Phi_s$  in a range of 10 to 200  $\mu\text{m}$  (preferably 20 to 100  $\mu\text{m}$ ), like the first embodiment, as shown Fig.6, and that an average ratio of the "pore inlet diameter  $\Phi_s$ " to 20 a "pore inside diameter  $\Phi_i$ " is at least 2.0 in the said pore 101 (preferably in a range from 2 to 20, more preferably from 5 to 20). As above described, porosity here is in the range of 2-35 volume % (preferably 10 to 25 volume %).

As there exist a lot of pores 101 (open pores) as above, the resin 25 film layer 3 is allowed to enter these open pores 101, thus rigidly fixing the resin film layer 3 to the bearing body 11. Further, as the pores 101 which are open on the end face 11A of the bearing body 11 are sealed by the resin film layer 3, the lubricant leakage therefrom is controlled. Moreover, coating is applied to the surface of the bearing body by printing 30 or the like, without applying any chemical treatment thereto, yet the solid lubricant coating 110 enters fine irregularities 102 on the surface of

the end face 11A. Specifically, the sizing process facilitates the resin film layer 3 to enter into the open pores 101 and irregularities 102, thus improving the tightness therebetween.

Fig.7 shows a sizing die assembly 21 used for sizing process. The 5 sizing die assembly 21 assumes that the vertical direction is its axial direction (pressing longitudinal direction), including a die 22, a core rod 23, a lower punch 24 and an upper punch 25. The die 22 is substantially cylindrical, with the column-shaped core rod 23 being positioned coaxially therewith.

10 The lower punch 24 is also formed substantially cylindrical, fitting in between the die 22 and the core rod 23 from a lower side, in a manner capable of moving up and down freely so that it may be taken in or out from there freely. The upper punch 25 is also formed substantially cylindrical, fitting in between the die 22 and the core rod 23 from an 15 upper side, in a manner capable of moving up and down freely so that it may be taken in or out from there freely. As shown in Fig.7, the bearing body 11 is placed inside the die 22 with the core rod 23 being positioned in the through-hole 12 serving as a sliding surface of the bearing body 11. Then, the bearing body 11 is pressed from the upper and lower directions, 20 using the upper and lower punches 25 and 24 so that the bearing body 11 is corrected to take a proper size. Due to the pressure applied at that moment, the resin film layer 3 is pressed against the end face 11A serving as a sliding surface.

Fig.8 illustrates surface roughness of the resin film layer 3. For 25 the resin film layer 3 is used the solid lubricant coating comprising a blend of 100 parts by weight of screen process ink (product name: "SS25-000" by Toyo Ink Seizo K.K.) and 30 parts by weight of PTFE having an average particle diameter 50  $\mu\text{m}$ . The solid lubricant coating was printed on the said end face 11A so that the resin film layer 3 was 30 formed. Also, in the sizing process, pressure was applied for two or three seconds, at 100-300 MPa, so that the resin film layer 3 was pressed

against the end face 11A.

It is understood that Fig. 8(A) shows the surface roughness of the resin film layer 3 before the sizing process, while Fig. 8(B) shows that after the sizing process, and that the irregularities of the resin film layer 5 3 were reduced and thus the layer 3 was smoothed.

As the resin film layer 3 is provided on the end face 11, and the resin film layer 3 is pressed by pressing forces applied by the upper and lower punches 24, 25, orthogonally relative to the end face 11A, so that the tightness between the resin film layer 3 and the end face 11A is 10 ensured, enabling the smoothing of the resin film layer 3 simultaneously.

Figs. 9-11 show another embodiment of the invention, in which the repeated detailed descriptions of the same portions will be omitted like the foregoing embodiments.

In the present embodiment showing the bearing body 11, as 15 illustrated in Fig.9, two or more dynamic pressure generating grooves 5 are arranged equidistantly along circumferential directions between arc portions 3A of the resin film layer 3. It should be noted that the dynamic pressure generation grooves 5 are defined by not providing the resin film layer 3, thus forming the dynamic pressure generation grooves 5 each 20 having a depth corresponding to the thickness T of the resin film layer 3. The end face 11A is exposed to the external in the dynamic pressure grooves 5, while the dynamic pressure generation grooves 5 are tapered toward the center, such that the arc portions 3A of the resin film layer 3 and the dynamic pressure generation grooves 5 are arranged alternately 25 in a manner like a vortex as a whole. In that case, it is easy to form the dynamic pressure generation grooves 5, using silkscreen printing, by matching the pattern formation layer 113 to the pattern of the resin film layer 3 as shown in Fig. 11.

The lubricant included in the pores of the bearing body 11 oozes in 30 association with the rotation of the axial body 13 which axially supports the bearing body 11, thus forming an oil film between the peripheral

inner surface (which serves as a sliding surface) of the through-hole 12 of the bearing body 11 and the peripheral outer surface of the axial body 13 as well as between the end face 11A of the bearing body 11 and the ring 14 fixed integrally to the axial body 13. The oozed lubricant is, in 5 association with the rotation of the axial body 13, flows in the rotational direction of the axial body 13, along the dynamic pressure generation grooves 5 formed on the end face 11A on one side of the bearing body 11 sliding relative to the ring 14, thus producing pressure, generating dynamic pressure, i.e., oil pressure in the direction supporting the axial 10 body 13.

As is apparent from the foregoing, whilst the lubricant included in the pores of the bearing body 11 oozes in association with the rotation of the axial body 13, a portion of the end face 11A which is covered with the resin film layer 3 is prevented from the lubricant's leakage, and the 15 leakage of the lubricant only occurs in the dynamic pressure generation grooves 5 formed in the resin film layer 3. Further, as the ring 14 which regulates the thrust movement of the axial body 13 does not come into direct contact with the bearing body 11 but into contact with the resin film layer 3, the abrasion of the end face 11A of the bearing body 11, said 20 end face 11A serving as a sliding surface relative to the ring 14, is suppressed, thus eventually preventing the abrasion of the dynamic pressure generation grooves 5 since the dynamic pressure generation grooves 5 are formed by the resin film layer 3. As a result, a high dynamic pressure can be maintained in the dynamic pressure generation grooves 5. 25 Moreover, as the resin film layer 3 which forms the dynamic pressure generation grooves 5 is formed on the bearing body 11 by the coating process such as printing, dynamic pressure generation grooves 5 can be formed extremely easily as compared with conventional methods such as cutting using a NC lathe and rolling. Additionally, compacting accuracy of 30 the dynamic pressure generation grooves 5 improves, thus realizing an excellent dynamic pressure characteristic. Practically, the resin film layer

3 of a desirable shape can be formed, by using a screen process printing.

The present embodiment is particularly advantageous, in addition to the above-mentioned advantages of the foregoing embodiments, in that the formation process of the dynamic pressure generation grooves 5 is 5 simply performed, as the bearing body 11 is formed with the resin film layer 3 by printing process, while forming the dynamic pressure generation grooves 5 by providing blanks in printing.

In Fig.12 showing a fourth embodiment of the invention, the resin film layer 3 is formed in the through-hole 12 (serving as the sliding 10 surface) of the bearing body 11 by the coating process such as printing. Therefore, the friction between the through-hole 12 and the axial body 13 can be reduced due to the resin film layer 3 in which the solid lubricant is dispersed.

As the resin film layer 3 is provided in the through-hole 12 in the 15 bearing body 11 of which the porosity is 2-35%, the friction between the axial body 13 and the through-hole 12 as a sliding surface can be reduced, thus attaining the same effect and action as the foregoing embodiments.

In Figs.13-16 showing a fifth embodiment of the invention, the sintered bearing 10 of this embodiment includes the bearing body 11 20 formed by sintering a green compact obtained by compacting material powders, and the resin film layer 3 formed integrally with the end face 11A of the bearing body 11 by resin coating process, in which said resin film layer 3 serves as a washer member 14 in this embodiment. The sintered bearing 10 supports the shaft S rotatably, retaining lubricant in 25 the bearing body 11 composed of the sintered alloy body, enabling the lubricant to ooze from a peripheral inner surface 11B by rotating the shaft S. The shaft S is subjected to a thrust load in the direction indicated by an arrow as shown in Fig.14, while a snap ring R is press-fitted through the shaft S and abuts to the sintered bearing 10 through two or 30 more washers WA, WB, WC, thus regulating thrust movement thereof. In the meantime, this sintered bearing 10 is a so-called ball bearing, which

is capable of automatic core-adjustment as a side surface 11C is formed spherical.

The bearing body 11 is a cylindrical sintered body obtained by compacting metallic material powders such as iron and copper, and then 5 sintering a green compact thus molded,

As there exist a lot of pores (open pores) on the end face 11A of the bearing body 11, as shown in Fig.15, the resin film layer 3 is allowed to enter these open pores, thus rigidly fixing the washer 14 (made of the resin film layer 3) to the bearing body 11. Further, as the pores which are 10 open on the end face 11A of the bearing body 11 are sealed by the washer 14, the lubricant leakage therefrom is controlled.

For resin coating which makes up the washer member 14 may be employed a mixture of certain resin having adhesion properties, used as adhesion matrix, and certain solid lubricant. For the solid lubricant may 15 be used the one which improves the lubricating properties of the washer member made of the resin film layer 3. For example, PTFE ("Teflon" (registered trademark), C (graphite), MoS<sub>2</sub> (molybdenum disulfide), BN (boron nitride), WF (tungsten fluoride), and TiN (titanium nitride) or the like may be used, which may be used alone or in a mixture thereof.

20 In the meantime, the solid lubricant of the invention includes hard particles for imparting lubricating properties, such as sericite. Alternatively, resin that has lubricating properties itself may be applied to form the washer member 14, without mixing the solid lubricant. Whilst 25 coating is employed to form the resin film layer 3, various methods may be employed as long as they are able to form the resin film layer 3 on the end face 11A. Incidentally, the thickness T of the washer member 14 is desirably 0.1 mm or more.

The thickness T is defined by the distance between the end face 11A and the outer surface of the washer member 14. The washer member 30 14 has an inside diameter which is larger than the outside diameter of the shaft S (i.e., loose fit) so that the peripheral inner surface 12A may

not slide on the peripheral surface of the shaft S, while the outside diameter of the washer member 14 is formed as large as possible. That is, as the washer member 14 is so formed that the peripheral inner surface 12A does not contact the peripheral surface of the shaft S, it is not subjected to any force developed in the rotational direction of the shaft S.

5 Also, as the outside diameter of the washer member 14 is formed larger than the washer WC contacting the washer member 14 directly, the abrasion of the washer WC due to contacting and sliding on the end face 11A of the bearing body 11 is prevented.

10 After forming the washer member 14 made of the resin film layer 3 integrally on the bearing body 11 in this way, the sizing process is performed so as to allow the sintered bearing 10 to take a proper predetermined size, and then oil is supplied to the bearing body 11 to impregnate it with oil.

15 In the meantime, the washer WA is pressed into the shaft S, and the snap ring R and the washer WA are rotated integrally, while the washers WB and WC are loose-fitted to the shaft S, whereby it is possible to limit sliding surfaces only to contact surfaces between adjacent resins, such as a contact surface between the washer WA and the washer WB, or 20 a contact surface between the washer WC and the washer member 14, whereby the sliding between the washer WA and the snap ring R is suppressed, thus reducing the abrasion of the washer WA.

25 According to the present embodiment, as the washer member 14 made of the resin film layer 3 is integrally provided on at least one of the end faces 11A of the bearing body 11, and thus the washer member 14 is integrated with the bearing body 11, so that the relative rotation between the bearing body 11 made of sintered alloy and the washer member 14 made of resin is suppressed, rather resulting to the sliding between the washer member 14 and the other washers, or to the sliding between the 30 washer member 14 and the snap ring R, thus ensuring the preventing of the abrasion of the washer member 14 due to the sliding relative to the

bearing body 11. Moreover, as the washer member 14 can seal the pores on the end face 11A of the bearing body 11, the oil leakage from the end face 11A of the bearing can be prevented effectively.

As described above, as the washer member 14 includes the solid 5 lubricant in this embodiment, the lubricating properties are improved. As the resin coating is applied in the form of adhesion matrix, the washer member 14 can contain comparatively a lot of solid lubricant therein.

Also, according to the present embodiment, there is provided a method of manufacturing a sintered bearing, said sintered bearing 10 includes: the bearing body 11 formed by sintering a green compact obtained by compacting material powders; and the washer member 14 made of the resin film layer 3, said washer member 14 being provided on at least one of the end faces 11A of the bearing body 11, wherein said washer member 14 is formed by applying the resin thereto, said resin 15 including the solid lubricant.

Accordingly, the washer member 14 is formed integrally with the bearing body 11, so that the relative rotation between the bearing body 11 made of sintered alloy and the washer member 14 made of resin is suppressed, rather resulting to the sliding between the washer member 20 14 and the other washers, or to the sliding between the washer member 14 and the snap ring R, thus ensuring the preventing of the abrasion of the washer member 14 due to the sliding relative to the bearing body 11. Moreover, as the washer member 14 can seal the pores on the end face 11A of the bearing body 11, the oil leakage from the end face 11A of the bearing can be prevented effectively. In addition, owing to the solid 25 lubricant included in the washer member 14, the lubricating properties thereof are improved, and that since the resin coating is applied in the form of adhesion matrix, comparatively a lot of solid lubricant can be contained in the washer member 14.

30 It is also noted that the present embodiment is advantageous in that the sintered bearing 10 inclusive of the washer member 14 can be

finished to a precise dimension, as the sizing process is performed after providing the washer member 14 in the bearing body 11.

Referring to Fig.17 showing a sixth embodiment of the invention, the washer member 14 is composed of two layers, i.e., the resin film layers 3 and 3' provided on the end face 11A. Initially, the first layer (i.e., the resin film layer 3) is formed on the end face 11A, and then the second layer (i.e., the resin film layer 3') is formed on the first resin film layer 3. The thickness T' of the washer member 14 can be formed thick by providing the resin film layers in such multi-layer formation. Moreover, a desired performance of the washer, such as good lubricating properties, can be obtained by including lubricant at least in the resin film layer 3' that is exposed to the surface.

Referring to Fig.18 showing another embodiment of the invention, a sintered bearing 30 of the embodiment is a self-aligning bearing of which the surface contacting a housing H is formed substantially spherical. A washer member 32 is provided so as to cover a lower part of a bearing body 31 (the sintered alloy body) from a lower end face 31A to a lower part of a side face 31D thereof. A washer member 33 is provided so as to cover an upper part of the bearing body 31 from an upper end face 31C to an upper part of the side face 31D thereof. These washer members 32 ad 33 are provided integrally on the bearing body 31 by resin coating, and are pressingly held relative to the housing H by a spring washer WD.

The washer members 32 and 33 are each composed of a single layer of the resin film layer 3 or multiple layers thereof, like the foregoing washer member 14. The washer members 32 and 33 are each fixed in such a manner that covers the bearing body 31 from the lower end face 31A to the lower part of the side face 31D, and from the upper end face 31C to the upper part of the side face 31D thereof, respectively, thereby forming opposite end faces 30C and 30A, and side faces 30B of the sintered bearing 30. Like the foregoing embodiments, the washer members 32 and 33 are rigidly fixed to the bearing body 31 due to the

resin in a molten state entering the open pores on the end face 31A of the bearing body 31.

The sintered bearing 30 thus formed is held pressingly relative to the housing H by the spring washer WD made of a metallic material 5 which has a spring characteristic such as copper sheet, so that it is self-aligned. According to the sintered bearing 30 of the present embodiment, the spring washer WD is allowed to abut to the washer member 33 made of the resin, which means that the one pressed against the housing H is the washer member 32 made of the resin, thereby enabling the reduction 10 of the friction of the sintered bearing 30 relative to the housing H and the spring washer WD, realizing the smooth self-aligning of the bearing.

It is to be noted herein that in this sintered bearing 30 showing in Fig. 18, the resin coating is not applied to a central part on the side 31D of the bearing body 31, and thus the sintered surface is exposed to the 15 outside in an annular manner. This sintered surface serves as an oil-refilling surface 30B for supplying lubricant to the sintered bearing 30 (bearing body 31) from an oil refilling mechanism F which is made of felt, for example, and disposed along the outer periphery of the sintered bearing 30. In the event that the lubricant retained in the sintered 20 bearing 30 decreases due for example to the consumption thereof by the rotation of the shaft S or to the oil leakage, the lubricant can be supplied to the sintered bearing 30 (bearing body 31) from the oil refilling mechanism F through the oil refilling surface 30B where no resin is fixed.

Referring to Fig. 19 showing another embodiment of the invention, 25 a sintered bearing 34 of the present embodiment does not provide the oil refilling surface 30B described in the seventh embodiment, but forms the single or multi-layered resin film layers 3 in a manner covering both end faces 35A, 35C and side surface 35B entirely. With such structure, it is possible to prevent the lubricant from oozing from both end faces 35A, 30 35C and the side surface 35B of the bearing body 35 owing to a washer member 36, thus eliminating the need for the oil refilling mechanism,

enabling the simplifying of the structure around the bearing.

It should be noted that the present invention should not be limited to the above-mentioned embodiments but various modifications are possible within the scope of the invention. Resins and solid lubricants 5 should not be limited to the described ones, but various kinds and types thereof may be used. The sintered alloy of the invention may be applicable to other various configurations

As is apparent from the foregoing, the present invention provides a sintered alloy which enables the reducing of coefficient of friction and 10 the sealing of pores on a surface thereof as well as a method of manufacturing the same. The invention is applicable to sliding components such as bearings and other devices.